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(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors: AIRY, Manish; 5701 Sandshell Drive, #2004, Fort Worth, TX 76137 (US). ROHANI, Kamyar; 1918 Waterford Drive, Grapevine, TX 76051 (US).

(74) Agents: TERRY, L., Bruce; Motorola Inc., Legal Department, Mail Stop E230, 5401 North Beach Street, Fort Worth, TX 76114 et al. (US).

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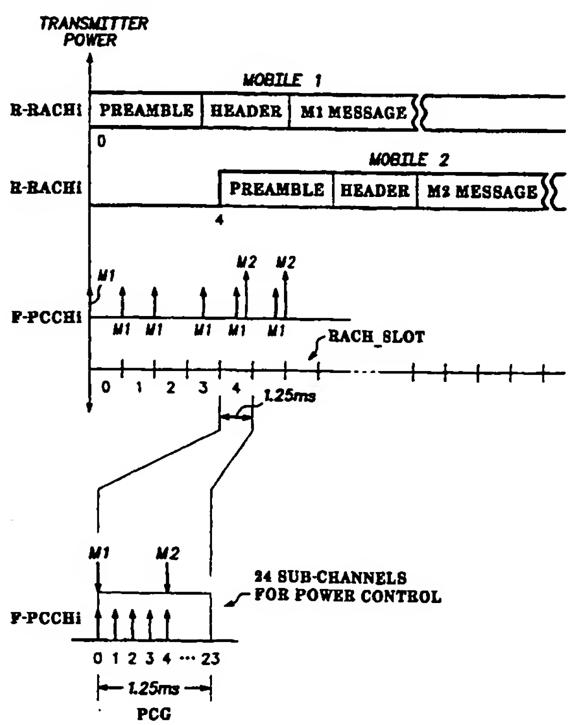
(54) Title: FAST POWER CONTROL TO MOBILE STATIONS SIMULTANEOUSLY INITIATING A RANDOM ACCESS TRANSMISSION



(57) Abstract: A method for providing fast power control to mobile stations simultaneously initiating a random access transmission to a base station in a communication system is disclosed. The mobile station does not wait for an acknowledgement of successful detection prior to transmitting the header/message portion of the access Message and responding to power control bits on the associated F-PCCH sub-channel. The mobile will, however, abort transmission if no detection acknowledgement is received on a forward common channel within a predetermined timeout. If the base station detects an access preamble in any R-RACH slot, it starts a power control bit stream on the associated F-PCCH sub-channel.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FAST POWER CONTROL TO MOBILE STATIONS SIMULTANEOUSLY INITIATING A RANDOM ACCESS TRANSMISSION

Field of the Invention

The present invention relates to cellular communication systems and, more particularly, to a system for increasing the reliability of the cellular communication system in environments having a large number of mobile telephone units simultaneously attempting to access a base station.

Background of the Invention

In multi-access systems such as cellular communication systems, when several transmitters attempt to transmit simultaneously, the messages may interfere or collide with one another. A receiver may not be able to distinguish among the messages involved in the collision. Two such multi-access protocols, commonly called the "Aloha" and "Slotted Aloha" protocols, are described in Bertsekas et al, *Data Networks*, Chapter 4, Prentice-Hall, Englewood Cliffs, 1987. In the Aloha protocol, each transmitter may transmit a message at any time. Upon discovering that the transmitted message has collided, the transmitter waits a random delay time and retransmits the message. In Slotted Aloha, all messages fit into a time slot of a predetermined length. Upon discovering that the transmitted message has collided, the transmitter delays a random number of slots and then retransmits the message. In both methods, a random delay is introduced to prevent transmitters from retransmitting simultaneously.

The use of code division multiple access (CDMA) spread spectrum techniques maximizes the number of mobile stations that can communicate simultaneously with the base station. Each mobile station has a pseudo noise (PN) code uniquely associated with it that the mobile station uses to spread its transmitted signals, commonly referred to as the long PN code. Once the call has been initiated, i.e., the base station has selected the long PN code corresponding to

the transmitting mobile station, the base station can receive and despread the signal transmitted by the mobile station. Similarly, the mobile station can receive and despread the signal transmitted by the base station. In some systems, the signals may be modulated with a pilot PN code as well.

For certain types of transmissions, it is advantageous to use a common PN long code rather than a unique long code for each mobile station. The message transmitted by a mobile station attempting to initiate a call is one example of such a transmission. A mobile station wishing to initiate calls can transmit such requests on a common access channel using a corresponding common PN code. The base station can monitor the access channel by despreading of the signal using this PN code. The access channel is used because messages such as those initiating a call are relatively short in comparison to voice transmission, and a receiver can more easily monitor a relatively few access channels than the large number of unique traffic channels with which the mobile stations are associated by the unique PN long codes.

When two mobile stations transmit simultaneously and there is no multi-path, the transmissions arrive at the base station separated in time by a delay. Under most operating conditions, it is unlikely that a large number of mobile stations will be at the same distance from the base stations. However, simultaneously transmitted messages would collide if two or more are at the same range. Under most conditions, the base station can distinguish among the transmissions because the time between arrivals of the transmissions at the base station exceeds one PN chip.

The probability of access channel collisions increases with an increase in the number of mobile stations and with an increase in multi-path reflections. Multi-path compounds the problem because, while the main signals of two transmissions may be separated in time by more than one chip, multi-path components of the transmissions may not be.

In 2G systems (i.e. IS 95B), the reverse access channel employs slotted Aloha as the access protocol. In 3G systems (i.e. CDMA 2000), possible

enhancements to the existing access procedure include fast closed loop power control which provides up to 5 dB Eb/No reduction relative to IS 95B open loop power control. The power control bits on the forward link are transmitted on a common power control channel (F-PCCH). Since access transmissions are short, typically around 100 ms, fast response is required for power control to be effective.

The pseudo noise (PN) randomization procedure in IS 95 A/B allows the mobile station to delay its long code timing by a random number of chip durations between 0 and 511. If two mobile stations initiate access attempts in the same slot of the same reverse access channel (RACH), but with sufficient chip separation between them due to PN randomization, both transmissions may be successfully decoded by the base station. However, both mobile stations will now be power controlled by a single power control bit stream on the F-PCCH associated with the particular RACH on which the mobile station preambles were detected. If the base station is able to identify more than one transmission, it may choose to follow the strongest mobile station, randomly toggle power control bits up and down and effectively not have power control. If the base station is not able to reliably detect multiple simultaneous transmissions, the transmit powers of the accessing mobile stations listening to the same power control bit stream are a random walk with 1 dB steps. If unchecked, this random walk may introduce serious interference in the system, in that the random walk is a function of load and slot duration. In either case, associating power control bit streams on the F-PCCH with a particular RACH does not ensure unambiguous power control.

Therefore, a need exists for an improved method for providing fast power control to mobile stations simultaneously initiating a random access transmission to a base station in a communications system.

Brief Description of the Drawings

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by

reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 shows a timing diagram illustrating access channels for two mobiles and a fast power control channel;

FIG. 2 shows a functional flow diagram depicting the process of providing fast power control to mobile stations simultaneously initiating a random access transmission to a base station according to the method and the system of the present invention.

Detailed Description of the Invention

Referring now to the drawings, and in particular FIG. 1, a timing diagram illustrating Reverse Random Access Channels (R-RACH) for two mobile stations and a Forward Link Common Power Control Channel (F-PCCH) is shown. In the preferred embodiment, the R-RACH is used by the mobile station to initiate communication with the base station or to respond to a mobile station directed message. As seen in FIG. 1, each R-RACH Message comprises a preamble portion, followed by a header portion, followed by a message or data portion. Preferably, the frame duration for the R-RACH header is 5 ms in duration. In addition, transmissions on the R-RACH are slotted, with the slot interval on a given R-RACH being defined by the system parameter RACH_SLOT. In the preferred embodiment, there are 512 slots associated with a particular R-RACH, and the mobile station uses a different long code mask in each of the 512 slots. Preferably, the duration of each RACH_SLOT is 1.25 ms. The mobile stations M1 and M2 listen to the power control bits based upon the RACH_SLOT number. A power control bit is sent every 1.25 ms on the F-PCCH to signal the mobile station to increase or decrease its transmit power by a predetermined amount. The mobile station adjusts its transmit power every 1.25 ms (i.e. every power control group). The actual timing of F-PCCH may be delayed for a predetermined number of power control groups, thereby allowing the base station to detect the preamble as discussed in greater detail below. The number of available power control bits on

the F-PCCH in a single power control group is 24. Therefore, each F-PCCH can support 24 simultaneous access attempts. A single power control bit assigned in every power control group yields a power control rate of 800 bits per second. A single power control bit every alternate power control group yields a rate of 400 bits per second, etc.

IS 95B access procedures limit the maximum PN randomization offset to 512 chips. The mobile station uniformly delays the long code timing and the I and Q pilot PN sequences. As such, the base station searcher has to search for a preamble on the RACH long code and all possible offsets up to 512 chips. In contrast, the present invention proposes to parameterize the maximum possible offset to N chips, and define allowed offset slots or sub-channels – in other words, the notion of slotting the PN randomization interval into "sub-channels". Each offset slot is M chips long. M is large enough to account for cell radius and worst case multipath. Thus, each accessing mobile station delays its transmit timing and the long code generator state in discrete steps. To maintain the same searcher burden as in IS 95B systems, a typical value for M is 64, and a typical value for N is 512, thereby effectively yielding N/M = 8 sub-channels per R-RACH. In the preferred embodiment discussed above, N/M = 512. Each F-PCCH sub-channel is associated with each R-RACH slot through a non-random hash procedure. Each R-RACH slot has a different long code as discussed above. If the base station detects an access preamble in any R-RACH slot, it starts a power control bit stream on the associated F-PCCH sub-channel.

FIG. 2 is a flow diagram depicting a method for providing fast power control to mobile stations simultaneously initiating random access transmission to a base station in accordance with the present invention. The process may be initiated whenever the mobile station (not shown) must send information to the base station on a common access channel. For example, a user may initiate a telephone call, which must be routed to the base station. The flow begins at reference numeral 202, wherein prior to initiating a transmission, the mobile station randomly selects one of the available R_RACHs. In addition, the mobile

station receives the ID of the associated F-CACH, F-PCCH, and F-CCCH in a broadcast message from the base station. Thereafter, at reference numeral 204, the step of PN randomization is performed, wherein the mobile station time delays its access channel transmissions by a small amount that is greater than or equal to one chip, but is much less than the length of the message itself, as is well known in the art. Thereafter, at reference numeral 206, the step of transmitting a Message comprising a preamble, a header, and a message or data portion in the next R-RACH slot with index *i* is performed. Thereafter, at reference numeral 208, after a predetermined power control group delay, a response to the power control bits given by the associated F-PCCH is given. The power control sub-channels on the associated F-PCCH are determined by the R-RACH slot index *i*.

Thereafter, at reference numeral 210, a determination is made whether or not a detection acknowledgment on an associated F-CACH is received by the mobile station before detection timeout as follows: as soon as the base station detects a preamble, it sends an acknowledgment (i.e. detection acknowledgment) to the accessing mobile station on the Forward Common Assignment Channel (F-CACH) and starts sending power control bits. If the base station fails to detect the preamble, no detection acknowledgment or power control bits are sent. Typically, the detection acknowledgment is transmitted on a 5 ms frame to reduce delay. If the mobile station receives the detection acknowledgment, it continues transmission as shown at reference numeral 214. If the mobile station fails to receive the detection acknowledgment within a timeout period, it will abort transmission and perform a random backoff and power adjustment as shown at reference numeral 212 and as is well known in the art. It should be noted that the power adjustment described at reference numeral 212 should not be confused with fast power control. Thereafter, flow reverts back to the start. Possible causes for non-receipt of the detection acknowledgment include the preamble not being detected, or an error in the detection acknowledgment message itself. However, it should be noted that the mobile station does not wait for the detection acknowledgment message to transmit the header/message portion and respond to

power control bits on the associated F-PCCH sub-channel. In addition, it should be noted that the detection acknowledgment message is associated with a successful preamble detection on a sub-channel, and not with successful decoding of the access Message.

Thereafter, at reference numeral 216, a determination is made whether or not the mobile station receives a decode acknowledgment from the base station before decoding timeout. If the base station does not successfully decode the Message, then no decoding acknowledgment or power control bits are sent. If the base station does successfully decode the Message, it sends a decode acknowledgment on the F-CCCH to the mobile station. If the mobile station receives the decode acknowledgment, flow proceeds to the end. If the mobile station does not receive the decode acknowledgment, then the mobile will perform a random backoff and power adjustment as shown at reference numeral 218 and as is well known in the art. It should be noted that the power adjustment described at reference numeral 218 should not be confused with fast power control. Flow thereafter reverts back to the start.

If multiple transmissions occur in the same R-RACH slot, a collision occurs, and if the base station detects a preamble, it will start a power control bit stream corresponding to the R-RACH slot on which access was detected and power control the sum of the energies in the search window. If the base station fails to detect any preamble, it doesn't send a detection acknowledgment, and the colliding mobile stations abort transmission after a predetermined timeout.

It will be appreciated by those skilled in the art that the base station may choose to transmit an abort message on the F-CACH and stop transmitting the F-PCCH sub-channel to any accessing mobile station if system parameters so dictate.

The foregoing description of a preferred embodiment of the invention has been presented for the purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Modifications or variations are possible in light of the above teachings. The

embodiment was chosen and described to provide the best illustration of the principles of the invention and its practical application, and to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitle

Claims

What is claimed is:

1. A method for providing fast power control to mobile stations simultaneously initiating a random access transmission to a base station in a communication system, comprising the steps of:

generating a message;

delaying the message by a delay time corresponding to a random number of access slots;

transmitting the message on a channel whose identification is a function of the number of access slots delayed;

receiving power control bits on an associated broadcast channel whose identification is a function of the number of access slots delayed; and

monitoring a second associated broadcast channel from the base station for an acknowledgment.

2. A method as recited in claim 1, wherein the step of delaying comprises slotting PN randomization.

3. A method as recited in claim 1, wherein the step of receiving further includes the step of discarding a predetermined number of power control bits after initiating an access attempt.

4. A method as recited in claim 1, wherein the step of monitoring comprises monitoring the second associated broadcast channel from the base station for a detection acknowledgment and aborting the transmission if the detection acknowledgment is not received.

5. A method as recited in claim 1, wherein the step of monitoring comprises monitoring the second associated broadcast channel from the base station for a decoding acknowledgment.

6. A method as recited in claim 4, including the steps of performing a random backoff and performing a power adjust.

7. A method as recited in claim 5, including the steps of performing a random backoff and performing a power adjust.

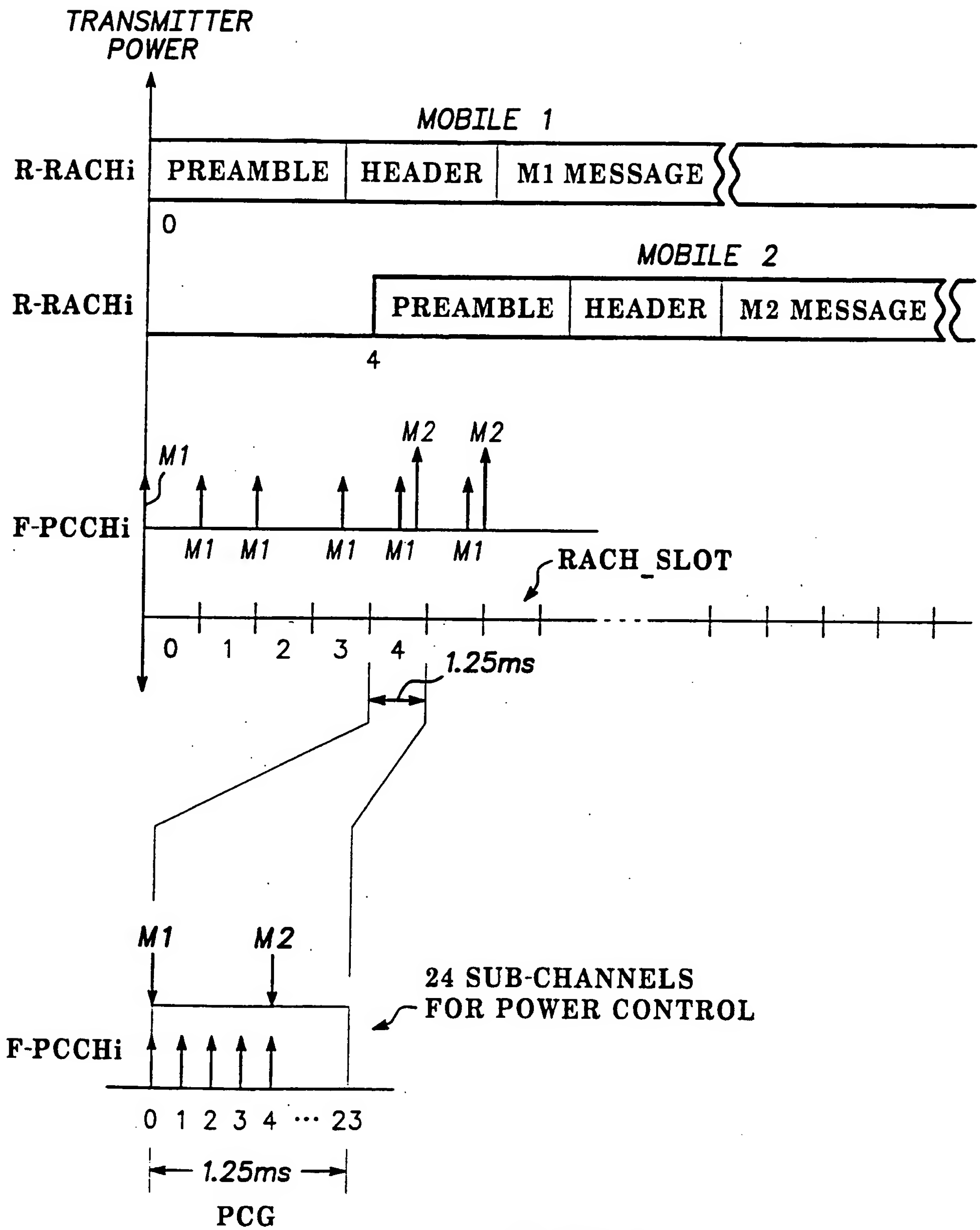
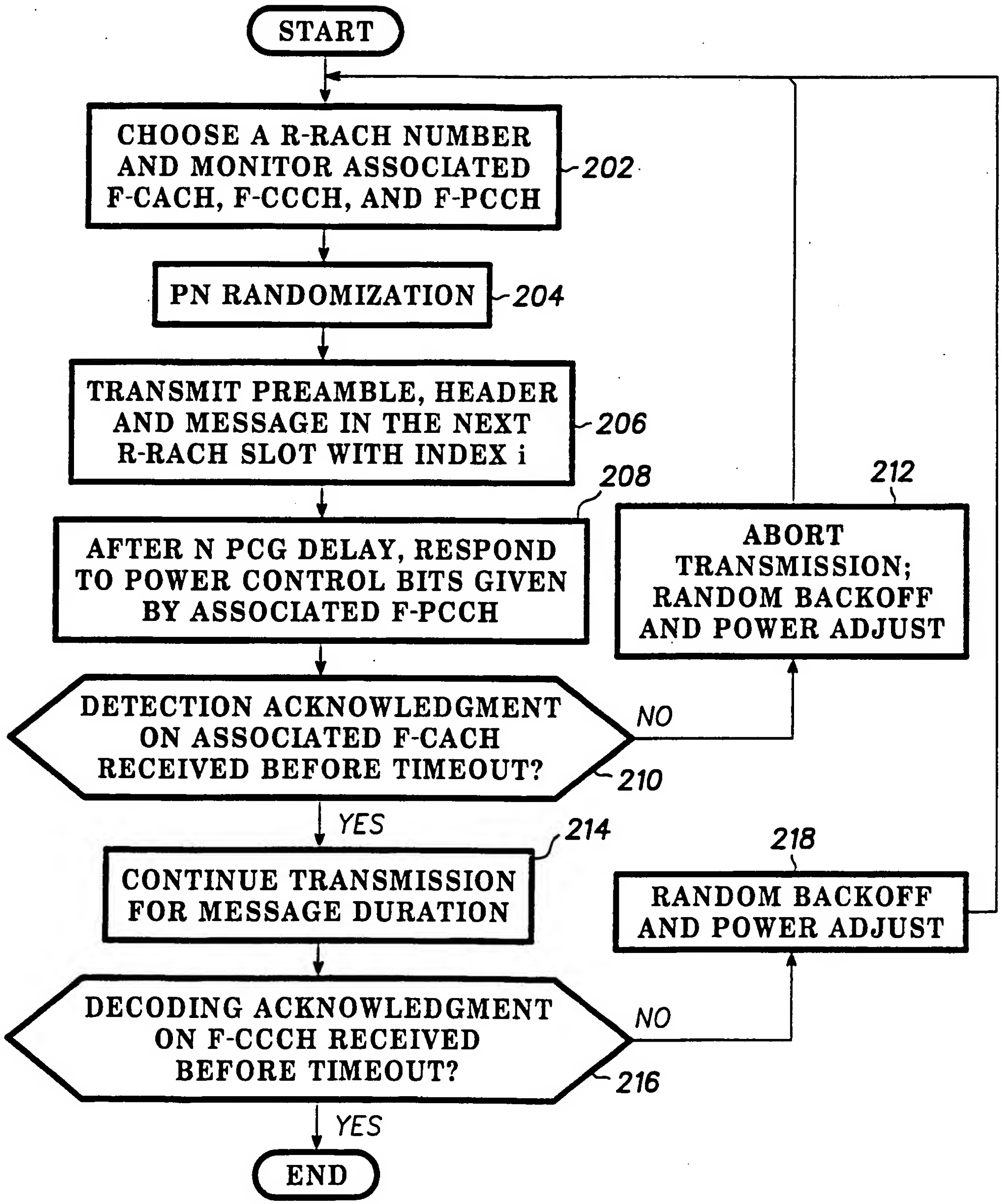

TRANSMITTER POWER
MOBILE 1
R-RACHi
PREAMBLE
HEADER
M1 MESSAGE
0
MOBILE 2
R-RACHi
PREAMBLE
HEADER
M2 MESSAGE
4
M1
M2
M2
F-PCCHi
M1
M1
M1
M1
M1
RACH_SLOT
0
1
2
3
4
1.25ms
M1
M2
24 SUB-CHANNELS FOR POWER CONTROL
F-PCCHi
0 1 2 3 4 ··· 23
1.25ms
PCG

FIG. 1



START
CHOOSE A R-RACH NUMBER AND MONITOR ASSOCIATED F-CACH, F-CCCH, AND F-PCCH
202
PN RANDOMIZATION
204
TRANSMIT PREAMBLE, HEADER AND MESSAGE IN THE NEXT R-RACH SLOT WITH INDEX i
206
208
AFTER N PCG DELAY, RESPOND TO POWER CONTROL BITS GIVEN BY ASSOCIATED F-PCCH
212
ABORT TRANSMISSION; RANDOM BACKOFF AND POWER ADJUST
DETECTION ACKNOWLEDGMENT ON ASSOCIATED F-CACH RECEIVED BEFORE TIMEOUT?
NO
210
YES
214
CONTINUE TRANSMISSION FOR MESSAGE DURATION
218
RANDOM BACKOFF AND POWER ADJUST
DECODING ACKNOWLEDGMENT ON F-CCCH RECEIVED BEFORE TIMEOUT?
NO
216
YES
END

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/30079

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04B 7/26
US CL :370/328, 347; 455/522
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/328, 347, 342, 345; 455/522

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,751,763 A (BRUCKERT) 12 May 1998, see entire document.	1-7
A, P	US 6,104,918 A (SAARIO et al.) 15 August 2000, see entire document.	1-7
A	US 5,768,684 A (GRUBB et al.) 16 June 1998, see entire document.	1-7
A	US 5,806,003 A (JOLMA et al.) 08 September 1998, see entire document.	1-7
A	US 5,881,368 A (GROB et al.) 09 March 1999, see entire document.	1-7
A	US 5,893,036 A (TRANDAI et al.) 06 April 1999, see entire document.	1-7

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer

MIN JUNG

Eugenia Logan

Telephone No. (703) 305-4363

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/30079

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,930,684 A (KESKITALO et al.) 27 July 1999, see entire document.	1-7